NEED TO KNOW
a national security newsletter

Volume 2, Number 1 October 2001

Idaho Accelerator Center Leads the Way in Research and Education

The pyramids rise from the rounded hills like a monument to some civilization, but not an ancient civilization. The Idaho Accelerator Center stands as a monument to the future.

At the Accelerator Center, the nature of physics is studied and solutions to global human problems – polluted soils, brain cancers, smuggled nuclear weapons, and aging and failing superstructures – are discovered and sent out into the world. Bright-eyed students and gray-headed researchers work side-by-side studying fundamental radiation science and developing practical accelerator applications.

Born of an alliance between the Idaho National Engineering and Environmental Laboratory and Idaho State University, the Accelerator Center acquires the strengths of both. From the university, the Accelerator Center takes basic nuclear research capabilities and the fresh ideas of students, led by seasoned researchers. From the INEEL, the Center takes nuclear engineering experience forged from 50 years of designing, building and testing reactors. Add to this an array of small accelerators not seen elsewhere in the world and the result is, according to Associate Director James Jones, a major, world-class research center.

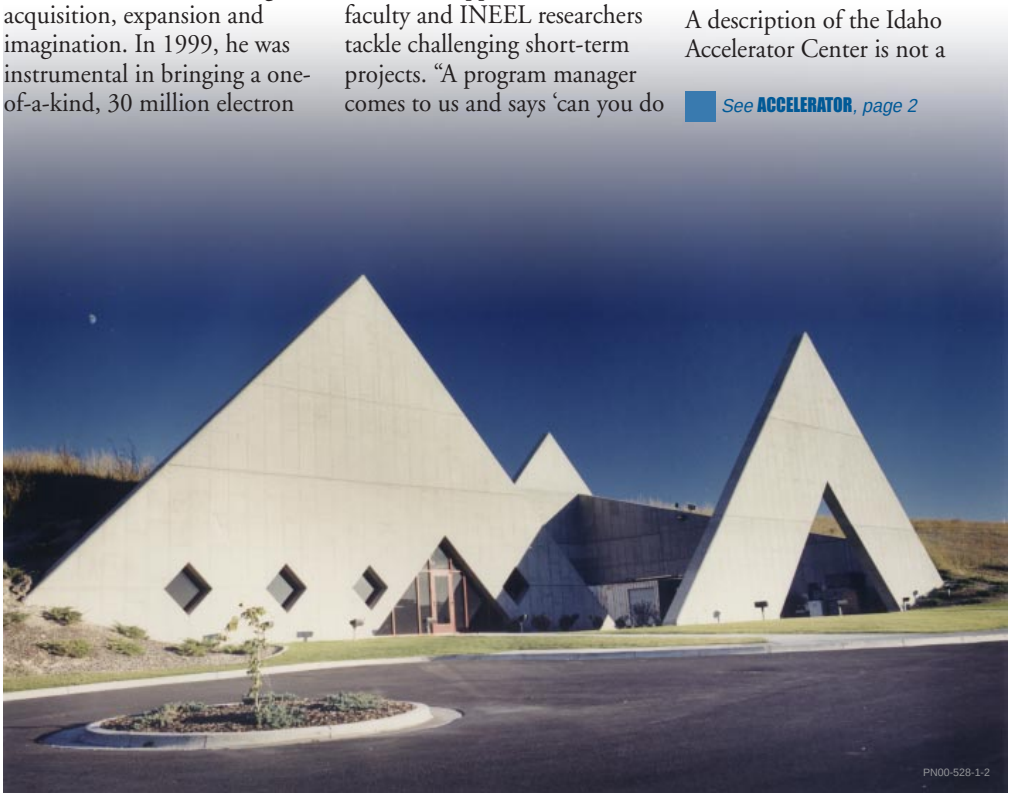
Jones, an INEEL physicist, has worked with the Idaho Accelerator Center alliance since its inception in 1994 and has seen it continue to evolve through acquisition, expansion and imagination. In 1999, he was instrumental in bringing a one-of-a-kind, 30 million electron volt linear accelerator to the shining, new university facility built into the foothills just north of the university's main campus.

But even Jones is surprised by the versatility and capabilities of the Center. "It's much more extensive than I ever envisioned," says Jones. "I thought it would be more R and D, but instead it's very problem focused." Driven by the INEEL deliverable approach, students, faculty and INEEL researchers tackle challenging short-term projects. "A program manager comes to us and says 'can you do this?' and we get the students, faculty, engineers and scientists figuring out a way."

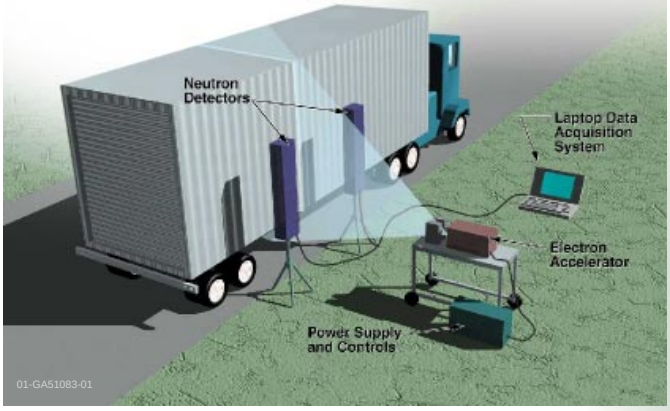
The Accelerator Center, however, owns another whole set of deliverables unlike any encountered by the INEEL. It is still an integral part of Idaho State University, and Director Frank Harmon and Jones never lose sight of student needs – education and diplomas. "The students get more than a great university education," says Jones. "They get unparalleled research opportunities and pragmatic problem-solving projects."

A description of the Idaho Accelerator Center is not a

See **ACCELERATOR**, page 2

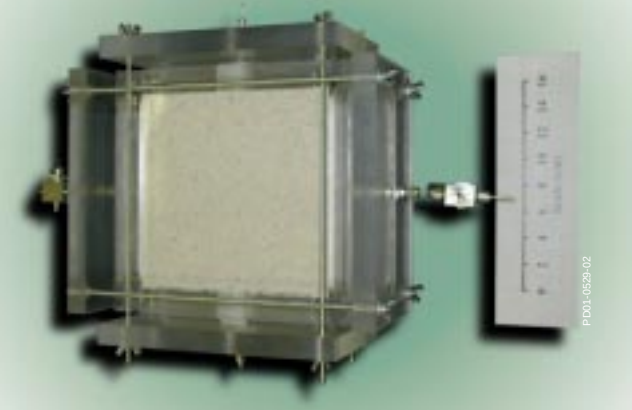


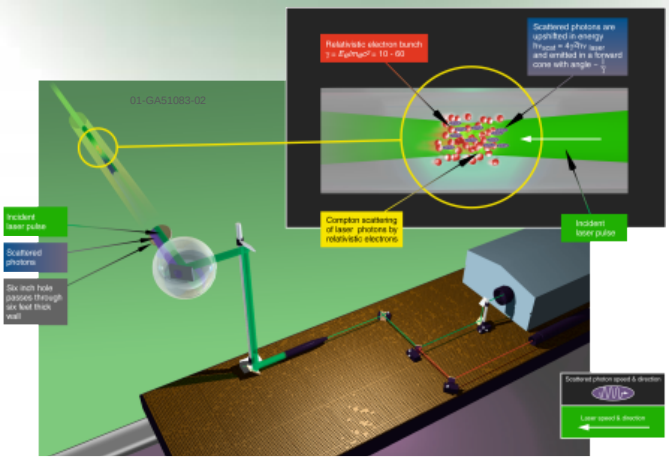
Researchers at the Idaho Accelerator Center are discovering solutions to global human problems – polluted soils, brain cancers, smuggled nuclear weapons, and aging and failing superstructures.



P²AS, or pulsed photoneutron activation system, is a nondestructive evaluation technique designed to address treaty verification, nuclear smuggling and contraband detection.

X-ray fluorescence detects heavy metals such as lead and mercury in soil columns. (photo by Jonathan Ferris)





This illustration depicts the Compton Backscatter research conducted at the Idaho Accelerator Center.

ACCELERATOR *(continued from page 1)*

simple litany of the myriad accelerators and neutron generators housed within its confines, nor is it images of the architecturally stimulating headquarters. An accurate picture of the Idaho Accelerator Center must include at least some glimpses into the research enfolding there and the solutions created there. Here are just a few.

Foiling Smugglers

It could have been taken from a chapter of a Tom Clancy thriller. A Frenchman and two cohorts were arrested in Paris trying to smuggle 80 percent-enriched uranium out of the country. They encased a glass vial in a lead cylinder and transported the package in a mundane delivery van. Fortunately, they were caught.

Investigators believe they stymied the delivery of a sample to potential buyers. Even with this arrest, customs service officials are worried. Who isn't caught? How much weapons grade uranium is being smuggled around the globe?

Certain types of radioactive materials, like medical, commercial and research isotopes are legal and transported every day. Smugglers attempt to shield illegal materials with lead and plastics. To make matters worse, 70 percent of manufactured goods are imported/exported in gigantic 40-foot cargo containers, an easy place to bury a wrapped and shielded package.

Jones and a team of researchers have proposed a solution. They use a pulsing electron accelerator to produce high-energy photons and aim them at a target. The energetic photons penetrate the target and stimulate photonuclear processes within the inspected object. The neutrons that result from this process are detected between each accelerator pulse and are used to identify any nuclear materials inside – whether shielded or not.

But to differentiate between legally shipped medical or commercial isotopes and perhaps terrorist-bound uranium, Jones shoots two different beam energies (from the same accelerator) at the target and analyzes the ratio of neutron counts that result.

Initial tests have successfully identified several types of nuclear material in various shielding configurations. Jones is conducting additional research in differentiating nuclear materials using a specialized photoneutron source that will preferentially induce neutrons in only highly enriched uranium. He sees the next steps as incorporating these active interrogation methods into existing inspection systems.

X-Ray Vision – Accelerator Superpowers

Moving from international borders to those closer to home, accelerator applications are supporting the INEEL's signature research focus, subsurface science.

Elements migrate through the subterranean labyrinth of rock and aquifer. How, at what speeds, and in which direction are just three of the innumerable questions scientists at the Laboratory are trying to answer. Theories and models are tested against samples taken from the subsurface. The sampling is meticulous and laborious. Accelerators might make it just a little easier.

Nowadays, scientists draw long columns of soil into the light, remove the material, and transport it to a lab for testing. Researchers at the Accelerator Center have developed a new nondestructive technique, called accelerator X-ray fluorescence or XRF, to identify potentially

migrating elements like lead, mercury or plutonium. They do this within the bulk sample, without removing the soil from the columns.

The tiny accelerator, not much longer than a clarinet, creates penetrating X-rays. But instead of seeing through the material, atomic fluorescence is produced by the process and is measured. Simultaneously, a germanium detector picks up the decaying positrons.

The combination of these subatomic processes has allowed the researchers to detect heavy metals in bulk media of soil and sand in parts-per-million. The post-doc and ISU student working on this Inland Northwest Research Alliance-funded project are seeing just how far they can push the technique. Right now, XRF easily penetrates the soil columns. Can it assay a 55-gallon drum? More research will bring more answers.

Making Waves

Moving from the subsurface to the subcutaneous, another accelerator application may make mammograms safer and clearer.

Conventional X-rays are generated with up to about 80 kilovolts of energy and subject patients to a small amount of radiation. That's how the image is made. So annual mammograms and dental X-rays all add up to a small dose. What if you could cut that dose in half while dramatically enhancing the X-ray image? Could you spot a tumor sooner?

These are the questions and the problem that another team of researchers are working on, but this time, using not just an accelerator but a laser, too.

Waves of energy emit colors, some visible to the human eye, some not. The higher the energy, the shorter the wavelength, the less visible the color. But it's still there. Accelerators and lasers emit energy of certain wavelengths. Laser light – think of a laser pointer – is just on the edge of visible.

When the waves of energy from a laser crash into the waves of electron energy from an accelerator, they convert the light to a new wavelength, a new color. This inelastic collision is likened to a baseball player hitting a ball. Lots of energy is released. And some of it is released as X-rays. This process, called Compton Backscattering, generates very clear X-rays in the 1- to 50-kilovolt range.

Creating this effect is not as simple as hitting that baseball. The laser pulses at 10 nanoseconds and the electrons from the accelerator pulse at 30 picoseconds or 3/10,000th of a microsecond. The collision must occur dead on, at exactly the right time. A hair right or left, a picosecond behind and only "jitters" are produced.

A "Positron" Influence

No industry wants to pay the cost of unpredicted material failure – in money, in downtime or in human life. To avoid failures and stay safe, many industries replace expensive parts well before the end of their productive life. A new INEEL process will not only predict material failure, it can determine remaining useful life, saving money and extending uninterrupted operation for critical components such as those used in airplanes, bridges and utilities.

A team of scientists is producing positrons with electron linear accelerators and using them to detect and measure subatomic structural defects. In July, Positron Systems, Inc., of Boise, Idaho, licensed the technology for commercial applications.

Scientists point a portable linear accelerator – similar to those systems used in cancer therapies – at a steel bridge support, an airplane wing spar or a plastic valve used in a human heart and shoot a beam of accelerator-produced, energetic photons at the material.

This process produces short-lived radiation in the material and gives off positrons – electrons with a positive charge. Positrons are attracted to the nano-sized defects of the material and as they decay, release their energy as unique gamma rays. The energy spectrum of the gamma rays creates a distinct and readable signature of the size, quantity and type of the defect.

Not satisfied with leaving well enough alone, researchers at the Accelerator Center are investigating another positron inspection process that uses photons produced from lower energy electron accelerators which completely avoids producing any short-lived radiation in the inspected material.

Using these processes, engineers could determine how long aircraft wings can be used, and bridge supports will stand. Medical manufacturers could confirm the quality of valves before doctors implant them into patients.

James L. Jones
jlj@inel.gov

Physicist Doug Akers led the research on the positron annihilation process, which has been licensed to Positron Systems, Inc. for commercial nondestructive testing applications.

INEEL Teams with U.S. Army to Assess Chemical Munitions

Some tasks require just a little extra effort to get the job done right. Not many require driving 3,600 miles or working around the clock during holiday weekends, but that's exactly what a National Security team did to ensure the success of the X300P90 project.

In typical military fashion, the simple title, X300P90, conceals a complex and exacting project. The U.S. Army asked the INEEL to design, build, deliver and support a system in Pine Bluff, Ark., to assess 1,273 recovered chemical munitions stored in 300 drums.

The assessment, performed by Echo Company of the U.S. Army Technical Escort Unit, was a two-part process. The drums were first X-rayed to verify the contents and position of munitions since some contained anywhere from one to 15 items. Drums containing a single munition were then assessed with the Portable Isotopic Neutron Spectroscopy (PINS) system to confirm the weapon's chemical content.

The information obtained by the project will help in the eventual destruction of this non-stockpile chemical materiel.

"We had ten months to get this operation completed," said National Security's Don Verrill, manager of the project. "We did it in seven." Verrill attributes some of the success to the superb cooperation and logistical coordination they received from the Product Manager for Non-stockpile Chemical Material and many organizations at Pine Bluff Arsenal.

Another factor contributing to the on-time, under budget project was the fact that Verrill insisted on staging the equipment on site weeks before the actual operation was to begin. This allowed the Army time to complete readiness reviews, develop operating procedures, and conduct final inspections.

Kenny Green, Tech Escort Unit toxic material handler, prepares a drum for assessment. The images at right show a digital radiograph and computed tomography (CT) slice of a 55-gallon drum. The radiograph shows several munitions within the drum. The CT slice reveals the number of munitions (nine in this drum). The images also help determine the presence and status of fuzes, burster, munition walls, or liquid. The image reveals a misshapen munition and a buildup of material (probably corrosion) on the inside wall.

To get all the gear to Arkansas in time, Verrill and team member Stacey Barker drove one equipment-laden trailer 1,800 miles in two and a half days, drove back to Idaho, then duplicated the trip two days later with the final shipment. In the meantime, the crew working on the X-ray

State of the Division

Laurin Dodd,
Associate Laboratory Director, National Security

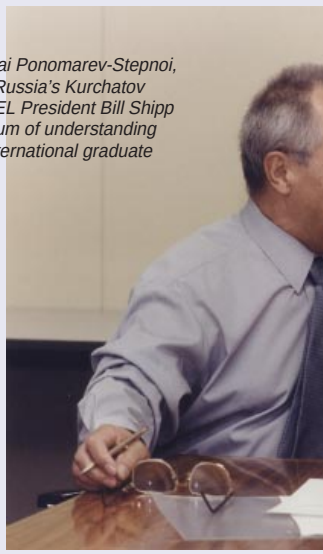
Our world changed this September when self-proclaimed enemies of the United States declared war against American citizens. But the whole world is not our enemy.

In fact, these sad events only made clearer the compassion and support felt and given by people and nations around the globe.

Many of us have received calls, notes and gestures from colleagues in far-off countries expressing their outrage against the acts and concern for our safety. I include these two.

Alexander Boronin and Vera Dmitrieva wrote, "We cannot find the right words to express our own and of all of us feelings with these horrible disasters. We think we are not mistaken to say that all Russia is shocked and in grieve. People are with tears in their eyes. It is not only your pain, it hurt all of us and we, we mean our countries and people of good will must become as close to each other as possible not only in these sad days but for ever. You have built a great country and we must unite our efforts to protect the people

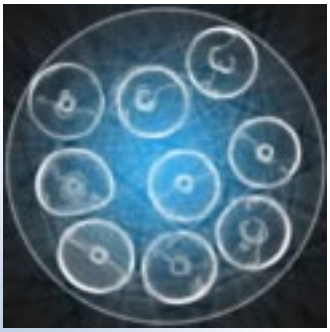
(left to right) Nikolai Ponomarev-Stepnoi, vice-president of Russia's Kurchatov Institute, and INEEL President Bill Shipp sign a memorandum of understanding establishing an international graduate student program.



equipment, Tim Roney, Tim White, Bob Pink and Idaho State University's Mike Smith worked a total of six man-weeks during one long Memorial Day weekend to finalize that system.

The team believed the efforts were worth it. "When someone at Pine Bluff Arsenal had a question," explained Verrill, "we were able to take him right over to the equipment and show him how it would operate."

Tim Roney, lead developer of the X-ray system, echoed Verrill's sentiments on working with Pine Bluff organizations. "We had to train and assist Tech Escort personnel on using the X-ray system. They were enthusiastic and highly motivated trainees. It made our job easier."



Working relationships aside, Roney and his colleagues encountered significant technical challenges. They had to design a precision X-ray system that would perform in a "hostile" environment. Temperatures in Arkansas swung from 110 hot humid degrees to traffic-stopping, ice-storm-causing, sub-freezing weather.

The sensitive equipment also had to be "ruggedized" to withstand not only the 1,800-mile initial trip but also subsequent moves from igloo to igloo. In fixed facilities, computed tomography systems are precisely aligned during installation. White led the effort to design and write new software and procedures to characterize and correct small losses in this critical alignment resulting from bumps and shifts in the multiple moves.

Another complication was the Army's insistence that for safety reasons, munitions be handled as little as possible. This resulted in having to leave drums in place while they were first X-rayed, then assessed with PINS. The team compensated by working many six-day weeks.

Was it worth it? The Army thought so. (See related story in Accomplishments, Achievements and Acknowledgments.) As for Verrill and company, they've never looked back. They are busy reconfiguring the system for the next Army project. In March they will again deliver a system to begin assessing thousands of ton containers also stored at the Arsenal. This time, they are hoping for better weather.

Don Verrill
vda@inel.gov

themselves and the treasures they created irrespective of what country they live. The Earth is our only home. Please accept our most sincere condolence and sympathy."

Dr. Alexander Rimski-Korsakov, Director General of Russia's Khlopin Radium Institute quietly returned an invoice, due him for travel and work at the INEEL, with instructions to donate his fee to a charitable organization benefiting survivors of the attack.

We are far from alone. Scientists and academicians throughout the world know us through our many cooperative research projects. We will continue to develop mutually beneficial relationships and programs.

The latest example of a beneficial relationship is the creation of an international graduate student research program with the Kurchatov Institute in Russia. Recently, Dr. Nikolai Ponomarev-Stepnoi, vice president of the institute, traveled to the INEEL, where he signed a memorandum of agreement between the laboratories establishing such a program.

This program provides experience and training for the best young minds of both countries to explore advanced science and engineering concepts, further encouraging careers in civilian applications.

The benefits of international programs go beyond the formation of strong relationships and sound understanding. Experts in environmental management and nuclear physics exist on both sides of the world. Sharing technical solutions can help resolve both nations' environmental problems.

Although the full impacts of recent events are just starting to evolve, it is clear that our nation's priorities are changing and there will be new opportunities to apply INEEL technologies. We will all welcome the chance to contribute to the new challenges.

Infrastructure Protection Systems keeping the home lights burning

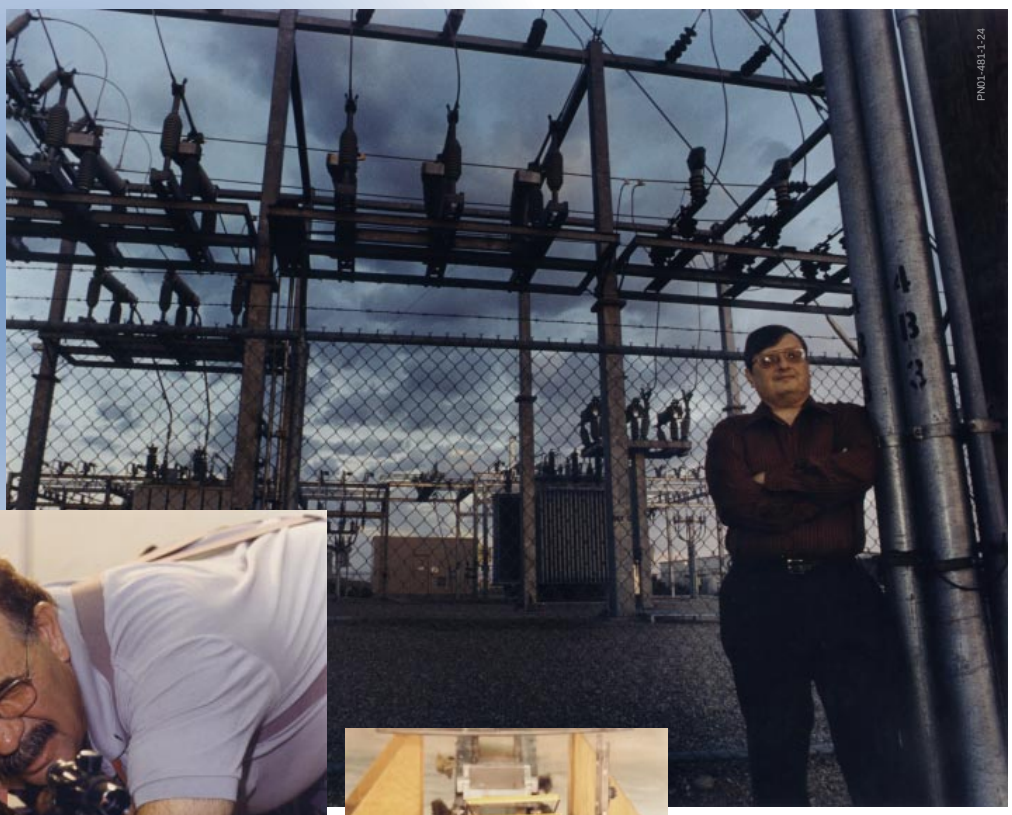
Where were you on Jan.17, 1994? If you lived in the West, you may remember. On that date, the Northridge, Calif., earthquake (6.7 on the Richter scale) struck, resulting in massive power failures and blackouts in seven states and British Columbia. Closer to home in Idaho, what were you doing on Valentines Day, 1999, when winds swept through the Snake River Valley with such force that many communities were left in the dark for days?

Outages disrupt businesses and endanger lives. It seems that we can't live without power for long. These disasters were caused by nature, "acts of God" in insurance terms. What if people – terrorists – could disrupt our power?

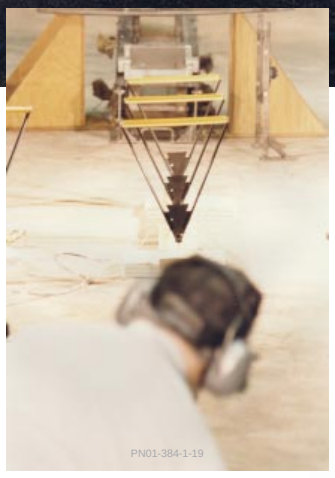
Changing Face of Warfare

The history of warfare, all the way through the Cold War, has been somewhat symmetrical, military against military. One gladiator picks up a sword; another gladiator picks up a larger one. One nation builds a bomb; another nation builds an even bigger one.

Steve Fernandez, manager of National Security's Infrastructure Protection Systems, explains how times have changed. "We are a superpower with no military peers. But what do we do when we pick up a sword and the enemy takes a hostage? We are now threatened on different fields; we have become vulnerable in those very areas that have created the strength of our society. Our interstates, airports, cyber networks, water, power and communication are all at risk to terrorist threats."



"A knowledgeable and capable adversary can launch an attack," says Steve Fernandez, manager of National Security's Infrastructure Protection Systems. "Our job is to warn, to protect and to ensure survival."



Kevin Anderson, facility manager for the Live Fire Range, zeros in a Russian AK-47 during field tests of a lightweight armor. A marksman fires through sensors at the target and the flattened rounds demonstrate the armor's success.

Inventor Lyle Roybal plays the part of an offender during a demonstration of the concealed weapons detector, currently installed at the Bannock County Courthouse.

That's why Clinton created Presidential Decision Directive 63, Critical Infrastructure Protection, and tasked the National Security Council with overseeing its implementation. The directive identified vulnerabilities in major categories such as banking, law enforcement, water and energy and assigned federal agencies as leads responsible for protection. The Department of Energy was assigned electric power, and oil and gas production and storage.

The INEEL is heavily engaged in projects protecting the nation's infrastructure. Fernandez' organization conducts and coordinates them. The projects fall into three main categories of physical, cyber and energy.

Protecting 'Things'

Out at the Live Fire Range at Central Facilities Area, marksmen carefully zero in using a Russian AK-47. The target is an innocuous, plastic-looking material 25 yards away.

Engineers have already subjected samples of the materials to freezing, baking, and soaking in salt water and will now oversee the final humiliation – shooting it. They are testing a lightweight armor for the U.S. Navy with the potential to replace everything from tank and ship armor to bulletproof glass and vests.

Standing guard, so to speak, at the Bannock County Courthouse is the concealed weapons detector. This INEEL-developed and -patented technology is a walk-through sensor system that pinpoints weapons such as knives and guns while eliminating many of the false alarms attributed to coins, keys and belt buckles. Marketed as SecureScan™ 2000 by Milestone Technology, the system may soon see its way into schools and airports. In the meantime, INEEL engineers are working on modifications to detect items restricted in some locations, like cell-phones and pagers.

The INEEL is heavily engaged in projects protecting the nation's infrastructure including several focusing on power.

Protecting 'Information'

Intruders are no longer just the black-garbed spies, slipping through locked doors in the dead of night. Nowadays, most intruders aren't even people, not in the traditional sense. Intruders are insidious, electronic trespassers of computer networks. They want to prove a point, steal information or wreak havoc. The INEEL alone receives thousands of "tickles" on its firewall daily, each representing someone looking at a path in. At the height of the Code Red virus, that number jumped tenfold.

One way to protect your network is by using SNORT, an intrusion detection system. INEEL computer engineers are experts in the system. Right now the INEEL is assisting the Defense Department's Global Network Operations and Security Center in developing a framework to incorporate SNORT into Pacific Command computer operations. Once successfully migrated into PACCOM, SNORT will be implanted across other military commands.

How to survive an intrusion is another information protection project, this one conducted in cooperation with the University of Idaho. Researchers are using LINUX systems to study the response to virus attacks and are working on computer "antibodies" to combat the virus.

Protecting 'Power'

The 1994 blackout caused by the California earthquake could have been averted with just a four-tenths-of-one-percent power cut to noncritical systems for 30 minutes. Instead, the quake precipitated a cascade of failures, bringing down power in the Western states. Hindsight.

The INEEL is working on delivering foresight by identifying what is called the "irreducible critical sub-network" or the absolute minimum that must continue running. Once identified, they will model the tens of thousands of nodes in utilities and their interdependencies. Then they'll attack them, viciously like a terrorist or maliciously like a disgruntled employee. This war gaming will supply the right information for predictive decision-making.

"A knowledgeable and capable adversary can launch an attack," says Fernandez. "Our job is to warn, to protect and to ensure survival."

Steve Fernandez
sfernand@inel.gov

Achievements, Accomplishments and Acknowledgments

Tom Hoff, representing Lt. Col. Christopher Ross, Product Manager for Non-Stockpile Chemical Materiel, traveled to Idaho Falls to present a National Security-led team with Certificates of Appreciation. Don Verrill, Tim Roney, Tim White, Bob Pink, Mike Smith, Bob White, Kevin Young, Jeff Young, Gus Caffrey, Brian Harlow, Ken Krebs and Rahmat Aryaeinajad were recognized for "…outstanding work performed in accomplishing the X300P90 Assessment Project at Pine Bluff Arsenal. They consistently demonstrated an exceptional ability to address difficult problems in a timely manner and develop meaningful and highly acceptable solutions. Their efforts reflect great credit upon themselves, the Product Management for Non-Stockpile Chemical Materiel, and the U.S. Army." The team represented successful collaboration between National Security, Physics, Nuclear and Radiological, and Idaho State University. (see related story on page 4).

Jennifer Zane, Laurie Lindgren, Rudy Regalado, William Orr, Robert Dineen, Bryce Anderson and Dan Kurkowski received the "Spirit of Excellence" Award for their "significant contributions of time and talent in support of the Business Systems Improvement Project's Work Management and Supply Chain system design, development and implementation."

- Kurt Welker published "The Software Maintainability Index Revisited" in the August issue of CROSSTALK, The Journal of Defense Software Engineering.
- John Svoboda, J. Richard Hess, Reed Hoskinson and David Harker submitted a patent application for "Methods and Systems for Seed Planting Management and Control."

Tom Hoff (shown left) presented Certificates of Appreciation to X300P90 team members (in front, holding certificates) Jeff Young, Don Verrill, Kevin Young, Rahmat Aryaeinajad, Ken Krebs (rear) Bob White, Brian Harlow, Gus Caffrey, Tim White, and Tim Roney. Not shown are Bob Pink and Mike Smith.

The certificates awarded to the X300P90 team included these medals from the Program Manager for Chemical Demilitarization (PMCD). The INEEL supports the PMCD with many programs and projects.

- Allen Anderson, Scott Bauer, Dennis Bingham, Kerry Klingler and Gary Palmer submitted a patent disclosure on "Method and Apparatus for Positional Sensing Using Radio Frequency Networks."
- Matthew Anderson, Mark McKay and Derek Wadsworth submitted a patent disclosure on "Resolution Gradient Solution."
- Rahmat Aryaeinejad has two papers accepted for the 2001 IEEE Nuclear Science Symposium. They are entitled "Handheld Device for Simultaneous Monitoring of Fast Neutrons and Gamma Rays" and "Using the Cockroft-Walton Voltage Multiplier Design in Handheld Device."
- Miles McQueen, Scott Matthew, Axel Krings (UI) and Scott Harrison (UI) wrote several recent refereed publications on collaborative research between the INEEL and the University of Idaho on survivable systems. These include; The 2001 International Symposium on Information Systems and Engineering (Las Vegas, USA): "Attack Recognition Based on Kernel Attack Signatures"; The International Conference on Parallel and Distributed Computing Systems (Anaheim, USA): "Low-Level Network Attack Recognition: A Signature Based Approach"; The International Conference on Advances in Infrastructure for Electronic Business, Science, and Education on the Internet (L'Aguila, Italy): "A Two-Layer Approach to Survivability of Networked Computing Systems"; and The International Conference on Dependable Systems and Networks (Goteborg, Sweden): "An Agent Supported Bottom-Up Approach to Computer and Network Survivability".

NEED TO KNOW *is a publication of the National Security Division of the Idaho National Engineering and Environmental Laboratory. The INEEL is a science-based, applied engineering national laboratory dedicated to supporting the U.S. Department of Energy's missions in environment, energy, science and national security. The INEEL is operated for the DOE by Bechtel BWXT Idaho, LLC, in partnership with the Inland Northwest Research Alliance. Requests for additional copies, story ideas or questions should be directed to the editor at (208) 526-1058, kzc@inel.gov. This is printed on recycled paper.*

Editor ..... Kathy Gatens
Graphic artist .... David Combs
Photographers .. Mike Crane, Chris Morgan, Norm Free, Ron Paarmann
Copy editing ..... Rick Bolton

Visit our national security website at: www.inel.gov/nationalsecurity